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CULTURES OF UREDINEAE IN 1915¹

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The present article is the fourteenth of a series of reports² by the writer upon the culture of plant rusts, beginning in 1899 and completing seventeen consecutive years. With this report it is proposed to bring the series to a close. Hereafter the record of such cultures as may be undertaken will be made in whatever connection may be found advantageous. To render the work brought together in the present series more readily accessible, and to make clear the changing point of view dominating the work, it is proposed to prepare an index and a brief historical statement, to be issued in the early future.

During the year 1915, little traveling was undertaken for the purpose of securing culture material and information. Two trips were made by the writer, the first one in April, the second in June, the first one in company with Mr. H. E. Ford, in order once more to explore the Kankakee marshes, in the northern part of Indiana, especially to gather information about *Puccinia Seymouriana* on *Spartina*. The rust was found in the greatest profusion, and specimens were taken from different parts of the region. Only one of these specimens showed viability, without much strength, and no infection was obtained from it. It is difficult to surmise what could cause such low viability, especially as the winter was mild and favorable to vegetation.

Correspondents in various parts of the country, as in previous years, have sent material for cultures, of both the rusts and the living host plants. A number of correspondents took extra trouble to respond to requests for particular species, and to such

¹ Presented before the Botanical Society of America at the Columbus meeting, December 30, 1915.

² See Bot. Gaz. 29: 268-276; 35: 10-23; Jour. Myc. 8: 51-56; 10: 8-21; 11: 50-67; 12: 11-27; 13: 189-205; 14: 7-26; Mycol. 1: 225-256; 2: 213-240; 4: 7-33, 49-65; 7: 61-89.

especially not only the writer feels much indebted but the scientific public is placed under obligation. Among those who contributed in more or less degree to the studies of the present year the following are especially entitled to mention: Messrs. F. McAllister, I. M. Lewis and B. C. Tharp, Austin, Texas; W. A. Archer, Mesilla Park, N. Mex.; J. M. Bates, Red Cloud, Neb.; E. Bartholomew, Stockton, Kans.; E. Bethel, Denver, Colo.; J. F. Brenckle, Kulm, N. Dak.; H. L. Bolley, Fargo, N. Dak.; J. J. Davis, Madison, Wis.; A. O. Garrett, Salt Lake City, Utah; H. D. House, Albany, N. Y.; H. S. Jackson, Corvallis, Ore.; C. H. Kauffman and E. B. Mains, Ann Arbor, Mich.; Roy Latham, Orient, N. Y.; W. H. Long, Albuquerque, N. Mex.; C. R. Orton, State College, Pa; J. L. Weimer and H. H. Whetzel, Ithaca, N. Y.

To indicate the extent of the work in making the cultures here reported the following statistics may be given. There were available 118 collections with resting spores, and 18 with active spores, *i. e.*, taken from growing plants. Over 240 tests were made in a hanging drop to determine the germinating condition of the spores. Only 48 collections of resting teliospores could be brought to germination, from which 110 sowings were made, and 16 infections secured. From the 18 collections of fresh spores 34 sowings were made, and 3 infections obtained. No extra assistant was employed for the work, as has been customary in preceding years, but it was carried forward by the regular staff of the laboratory, the larger share falling to Mr. H. C. Travelbee.

NEGATIVE RESULTS.—A number of collections giving good germination of spores produced negative results when sown upon hosts which are presumably aecial hosts for the species, but possibly not adapted to the racial material in hand. A few collections of species, for which no definite suggestions were available, were sown upon the seemingly most likely aecial host. In both cases the lack of positive results appears worth recording.

I. PUCCINIA AMPHIGENA Diet., on *Calamovilfa longifolia* (Hook.) Hack., collected by Mr. E. Bethel at Colorado Springs, Colo., Oct. 18, 1914, and sent immediately to Lafayette, Ind.,

was sown March 31, on *Smilax hispida*; another collection from the same locality, made May 16, 1915, was sown on another plant of the same host May 24, both without infection. The leaves of the two collections sent by Mr. Bethel were thickly covered with the prominent, blackish telia. The teliospores germinated well, especially so in the October collection. Mr. Bethel stated on the label of the latter specimen that although the rust was very abundant, there were no *Smilax* plants in the region. In sending the May collection he stated on the label that the aecial stage occurred on *Leucocrinum*, but desired to have the material tested on *Smilax*. In the accompanying letter of same date he says: "I am inclosing *Puccinia amphigena* on *Calamovilfa longifolia*, which I wish you would sow on *Smilax*, which I believe you give as host in the east. I have fine young plants of native *Smilax*, but have failed to inoculate them. With us this does not normally belong to *Smilax*, and may be another race. It belongs to *Leucocrinum*, on which it is epidemic everywhere this year." This species of rust was first cultured on *Smilax* in 1902, from telial material gathered at Callaway, Neb., and in the year following from material gathered at the type locality in Chicago, Ill. It has been cultured altogether six times,³ the westernmost locality for telial material being central Nebraska, on the plains, some two hundred miles from the foothills of the Rocky Mountains, where this season's material was obtained.

2. PUCCINIA EMACULATA Schw., on *Panicum capillare* L., collected at Lafayette, Ind., was sown, May 21, on *Euphorbia corollata*, having shown strong germination, but without results. The reasons for this attempt, with citation of other trials, are given in the previous report of cultures.⁴

3. PUCCINIA SIMILLIMA Arth., on *Phragmites communis* Trin., collected by Dr. J. F. Brenckle, at Wiedmer's Lake, N. Dak., on April 11, 1915, was sown May 14, on *Anemone cylindrica* and *Ranunculus acris*, without infection. It was sown again June 18 on two plants of *Ranunculus sceleratus*, but with no infection.

³ See Bot. Gaz. 35: 20. 1903; Jour. Myc. 10: 11. 1904; 12: 16. 1906; 14: 15. 1908; Mycol. 2: 225. 1910; and 4: 18. 1912.

⁴ Mycol. 7: 65. 1915.

This species was successfully cultured in 1902 and again in 1907 on *Anemone canadensis*.⁵ A recent monographic study of American grass rusts confirms the early opinion⁶ that this species is similar, morphologically and in host requirements, to *P. Magnusiana* of Europe, which has been found to have aecia on *Ranunculus acris* and *R. bulbosus*. Aecia were collected by Dr. Brenckle on *R. sceleratus*, May 30, 1908, near Kulm, N. Dak., which are structurally similar to the American form on *Anemone*, as well as to the European form on *Ranunculus*. An appeal to Dr. Brenckle for living plants of *R. sceleratus* was met with some difficulty upon his part, but successfully, and telial material also was sent from a locality not far away from the place where aecia on *R. sceleratus* had been obtained, but nothing definite has been proven. It still seems probable, however, that *P. simillima* is but a racial variant of *P. Magnusiana*, and that a race may finally be found in America with aecia on *Ranunculus*, although the common form is on *Anemone*.

4. PUCCINIA RHAMNI (Pers.) Wettst., on *Nothololcus lanatus* (L.) Nash (*Holcus lanatus* L.), sent by Prof. H. S. Jackson from Corvallis, Ore., was sown April 2 on *Rhamnus cathartica* and *Lepargyrea canadensis*, with no infection. Another collection of the rust on *Scolochloa festuacea* (Willd.) Link, sent by Dr. J. F. Brenckle from Kulm, N. Dak., was sown May 8 on *Lepargyrea canadensis* and *Eleagnus argentea*, and again May 21 on *Rhamnus cathartica*, all without infection. Aecia are known to be common about Corvallis on *Rhamnus Purshiana*, but not found on *Lepargyrea*, the host being absent from the region, while at Kulm aecia are common on *Eleagnus*, but whether the latter belong to a race of *P. Rhamni*, or to an independent species is not yet known.

5. PUCCINIA AGROPYRI E. & Ev., on *Hordeum jubatum* L., sent by Dr. Brenckle from Wiedmer's Lake, N. Dak., was sown May 13 on *Anemone cylindrica*, *Clematis ligusticifolia*, and *Aquilegia* sp., without infection. Recent monographic study of the

⁵ Bot. Gaz. 35: 20. 1903; and Jour. Myc. 14: 15. 1908.

⁶ Arthur, The Uredineae occurring upon *Phragmites*, *Spartina* and *Arundinaria* in America. Bot. Gaz. 34: 18. 1902.

grass rusts has shown the probability that this form, usually reported under the name *P. rubigo-vera*, is a part of the comprehensive species, *P. Agropyri*, with aecia on different Ranunculaceous hosts, forming well defined races.⁷

6. *UROMYCES SCIRPI* (Cast.) Burr., on *Scirpus fluviatilis* (Torr.) A. Gray, sent by Dr. J. F. Brenckle from Kalmbach Lake, Lamoure Co., N. Dak., was sown March 26 on *Sium cicutaeifolium* and *Hydrocotyle australe*, and again May 19 on other plants of the same two species, without infection. The species apparently is made up of races, a study of which was the aim in this attempt at cultures.⁸

7. *UROMYCES ARCHERIANUS* Arth. & Fromme, on *Chloris elegans* H. B. K., collected Nov. 12, 1914, and again Feb. 7, 1915, by Mr. W. A. Archer, at Mesilla Park, N. Mex., was sown April 15, each collection on a different plant of *Chenopodium album*, with no infection. This new species of rust was discovered in abundance upon the campus of the New Mexico Agricultural College, with no distinctive aecia in the vicinity. Because of its morphological resemblance to *Uromyces Peckianus*, it was tried upon *Chenopodium*.

8. *AECIDIUM IRIDIS* Ger., on *Iris versicolor* L., from the Renwick Swamp, Ithaca, N. Y., was sent by Mr. J. L. Weimer in abundance and in excellent condition, and on July 1, the third day after collection, was sown on a large and especially thrifty plant of the same species of *Iris*, but gave no infection. A test of the spores showed that seventy-five to ninety per cent. were in germinating condition. Field observations have given little or no grounds for considering this rust autoecious, and the present trial further emphasizes this view. However, up to the present time no one has detected a probable alternate host.

SUCCESSFUL CULTURES SUPPLEMENTING PREVIOUS WORK.—The facts derived by growing the following species of rusts supplement in a variety of ways the facts obtained from previous cultures in this series from cultures recorded by other American

⁷ For previous attempts at cultures see Mycol. 2: 219. 1910.

⁸ For previous culture work see Jour. Myc. 13: 199. 1907; 14: 17. 1908; Mycol. 1: 237. 1909; and 7: 83. 1915.

or European investigators. The extension of aecial hosts for *Puccinia Seymouriana* to two families not closely related to the one previously known is especially important, and the behavior of rye rust upon *Anchusa* appears to have significance.

1. PUCCINIA EXTENSICOLA Plowr. (*P. Dulichii* Syd.).—A collection of this rust on *Dulichium arundinaceum*, made at DeMotte, in the Kankakee marshes of northern Indiana, by Mr. H. E. Ford and the writer on April 6, 1915, was sown April 19, on two plants of *Aster paniculatus*, one brought from the spot where the collection was made, and the prevailing plant at the place, and also on a plant of *Solidago canadensis*. Abundant pycnia began to show on the *Solidago* April 26, and aecia May 9, while the two *Aster* plants were unaffected. The result agrees with the facts obtained in 1914⁹ with similar material from Florida.

2. PUCCINIA GROSSULARIAE (Schum.) Lagerh.—Material collected by Mr. Roy Latham at Greenport, Long Island, N. Y., on *Carex tenuis*, was sown March 25 on *Ribes floridum* with no infection, and March 31 on *R. Cynosbati*, giving rise to pycnia April 13, and aecia May 4. The aeciospores thus produced were sown May 4 on *Carex pubescens*, with no infection. Another collection made by C. H. Kauffman and E. B. Mains at Lake Placid, N. Y., on *Carex arctata*, was sown March 15, on *Ribes Cynosbati*, giving a few pycnia March 26, but failing to develop further on account of injury to host. The same material was sown again March 26 on another plant of the same sort, giving pycnia April 2, and aecia April 26, the growth being slow. Both the original telial collections gave many urediniospores, all of which appeared to have but one basal pore, and they may be considered pure representatives of *Puccinia uniporula* Orton. The aecia were not distinguishable from those grown in previous years from material showing equatorially three-pored urediniospores. It was hoped that aecia so grown might be carried back to the telial host, and the character of the resulting urediniospores ascertained, but although an attempt was made, it failed.

A collection of aecia on *Ribes longiflorum* sent from Denver, Colo., by Mr. E. Bethel, was sown June 4, two days after collec-

⁹ Mycol. 7: 81. 1915.

tion, upon *Carex durifolia*, a species from which the aecia were supposed to have been derived, and also upon *C. Jamesii*, with no infection.¹⁰

3. PUCCINIA ERIOPHORI Thüm.—Observations by Dr. H. D. House of the New York State Museum, made near Oneida, N. Y., in June of this year, led to the recognition of this species of rust in America and the discovery of the alternate stage. On June 27 Dr. House wrote that “of thousands of plants of *Senecio* in the marsh practically every one is affected by the *Aecidium*.” He found that of the numerous marsh plants the one having a corresponding abundance of rust on the dead leaves from the preceding year was *Eriophorum viridi-carinatum*. At the same time he sent growing plants of both the *Senecio* and *Eriophorum*, the former with leaves well spotted with aecia. All the plants continued to flourish.

On June 30 a sowing of aeciospores from *Senecio aureus* was made on the young leaves of *Eriophorum viridi-carinatum*. After twenty-four hours a test of the spores remaining on the leaves of the *Eriophorum* showed that from twenty to forty per cent. of them were germinating. Daily observation of the plant was not made, but on July 15 both uredinia and telia were found to be present. The rust on American species of *Eriophorum* is morphologically very similar to *Puccinia angustata* Peck on various species of *Scirpus*, and usually has been listed under that name. As *P. angustata* has its alternate stage on the labiate, *Lycopus*, the same had been supposed to be true of the rust on *Eriophorum*, and thus to differ from the similar rust in Europe.

Tranzschel¹¹ has reported the infection in 1907 of *Ligularia sibirica* (*Senecio cacaliaefolius*) and *Senecio paluster* (*Cineraria palustris*) from teliospores on *Eriophorum angustifolium*, and has listed the European stations for the rust, showing that it is quite rare. In America it has been taken on *Eriophorum angustifolium* Roth, at Decorah, Iowa, June 29, 1884, E. W. D. Holway, Kennedy, Neb., July 20, 1892, J. M. Bates, Newfane, Vt., Oct. 16,

¹⁰ For previous cultures see Jour. Mycol. 12: 58. 1905; 12: 14. 1906; 13: 196. 1907; 14: 13. 1908; Mycol. 4: 13. 1912; and 7: 66, 78. 1915.

¹¹ Beiträge zur Biologie der Uredineen, III.

1892, *A. J. Grout*; on *E. polystachyon* L., Mt. Hood, Ore., at 5,000 feet altitude, July 23, 1915, *H. S. Jackson*; on *E. tenellum* Nutt., at Isle au Haute, Me., Sept. 11, 1899, *J. C. Arthur*; on *E. virginicum* L., at Avilla, Ind., August, 1884, *W. B. VanGorder*, Granville, Mass., August 1889, *A. B. Seymour* (*Seym. & Earle*, *Econ. Fungi* 54), Isle au Haute, Me., Sept. 6, 1899, *J. C. Arthur*, Central Village, Conn., Aug. 20, 1900, *John L. Sheldon*, Jackson, Ind., July 28, 1905, *C. C. Deam*, Elm Lake, Wis., Sept. 12, 1907, *C. L. Shear*, Winona Lake, Ind., Aug. 26, 1914, *G. N. Hoffer*; on *E. viridi-carinatum* (Engelm.) Fernald, at Avilla, Ind., August, 1884, *W. B. VanGorder*, Oneida, N. Y., June 27, 1915, *H. D. House*; on *Senecio aureus* L., at Buffalo, N. Y., without date, *G. W. Clinton*, Decorah, Iowa, June, 1883, *E. W. D. Holway*, Ann Arbor, Mich., June 8, 1898, *C. H. Kauffman*, Mt. Chocorua, N. H., July 3, 1906, *W. G. Farlow*, Radisson, Wis., July 6, 1906, *J. J. Davis*, Merrimac, Wis., June 19, 1912, *Davis & Arthur*, Oneida, N. Y., June 27, 1915, *H. D. House*; on *S. ductoris* Piper, Mt. Hood, Ore., at 5,000 feet altitude, July 23, 1915, *H. S. Jackson*. It is evident that the rust is widespread in America, especially northward, but not particularly abundant, and the aecia have been collected over nearly the same territory as have the telia.

The morphological differences between *P. angustata* and *P. Eriophori* are very considerable in the aecia, and while less marked in the uredinia and telia are yet noticeable. The urediniospores of *P. Eriophori* are more globoid, while the teliospores are somewhat shorter (35–60 μ long, against 42–67 μ in *P. angustata*) and the apex thinner (4–10 μ , against 7–16 μ in the other) with more tendency to acuteness.

4. PUCCINIA AGROPYRI E. & EV. (*P. alternans* Arth.)—A collection on *Festuca Thurberi* Vasey, sent from Lake Eldora, Colo., by Mr. E. Bethel, was sown May 13, on *Anemone cylindrica*, *Aquilegia canadensis*, *Clematis ligusticifolia*, and *Thalictrum dioicum*. Infection was obtained on the last named host only, which began to show pycnia May 23, and aecia May 30. In sending this material Mr. Bethel wrote that he thought it had been derived in the field from aecia on *Thalictrum Fendleri*, which the culture confirms as highly probable. The first collection of this

kind sent the writer by Mr. Bethel was dated Sept. 17, 1910, and was intended for cultures on *Thalictrum*. This could not be made to germinate when time for culture work arrived, nor could a half dozen other collections sent subsequently at various dates. With a specimen dated April 5, 1912, Mr. Bethel states that he has "proven by most positive field cultures" that it goes to *Thalictrum Fendleri*. Again in May, 1915, Mr. Bethel sent fine material from his garden, showing the telia that had been brought there and the aecia on *Thalictrum* derived therefrom. The reasons for listing the *Thalictrum* form under *P. Agropyri* were stated in the last report.¹² The aecia are especially large and prominent in this particular race on *Festuca*, as shown by a number of collections sent from the same locality.

5. PUCCINIA ASPERIFOLII (Pers.) Wettst.—Two plants of *Anchusa officinalis* L. were given ample space in the experimental garden of the Indiana Experiment Station and attained a fine development, each plant measuring five or six feet across. On July 2, the weather being especially damp with occasional light showers, stems of rye, heavily infested with rust, were laid upon the two plants in the garden, doubtless a hundred or more stems to each plant. The plants were not covered in any manner. The date of the appearance of the first pycnia was not recorded, but on July 13, the plants were conspicuously dotted with yellow spots bearing groups of pycnia. About a week later careful search brought to light two groups of aecia. Although the vigor of the plants and the condition of the weather seemed favorable, and the great numbers of yellow spots with their groups of pycnia continued to show, yet no further development of the rust took place.¹³

The reason why the infection should have started out with such marked vigor and yet failed to mature aecia is not at all apparent. The weather for the whole period was favorable for aecial growth. It is possible, and yet scarcely probable, that the explanation lies in the lessened vigor for the American rye rust, which is propagated by repeating spores alone, the aecial hosts being practically wanting in America.

¹² Mycol. 7: 74. 1915.

¹³ For a previous culture of similar character see Mycol. 1: 236. 1909.

6. PUCCINIA SEYMOURIANA Arth. (*Aecidium obesum* Arth.).—

This rust on *Spartina* at the time it was described in 1902 was predicted upon morphological and geographical grounds to have its alternate form upon the Rubiaceous genus *Cephalanthus*,¹⁴ the prediction being established by cultures in 1905, and confirmed in subsequent seasons.¹⁵ It was not until June, 1913, that additional suggestions came to light, when Rev. J. M. Bates wrote that his observations in the field led him to believe that in Nebraska this rust on *Spartina* was connected with an *Aecidium* on *Apocynum hypericifolium*. He sent a specimen of the aecia, which proved to be *Aecidium obesum* Arth. This collection was distributed as 4103 of Barth. Fungi Columbiani, and 1301 of Barth. N. Amer. Ured. Later in the year a careful microscopic comparison of these aecia with those on *Cephalanthus* established their essential similarity. Owing to adverse seasonal conditions Mr. Bates was unable to supply culture material for the 1914 cultures, but on May 8, 1915, he sent telial material on *Spartina Michauxiana* from Eight Mile Creek, near Red Cloud, Neb. It was sown May 12, on *Apocynum cannabinum*, *Amsonia salicifolia*, *Asclepias syriaca*, and *Cephalanthus occidentalis*, producing a scanty infection only on *Apocynum*, pycnia showing June 10, but without developing aecia.

A specimen of aecia on *Asclepias pulchra*, collected by Mr. Roy Latham, of Orient, N. Y., June 29, 1914, was reported to the collector upon cursory examination only, as aecia of *Puccinia Jamesiana*, that being the only species at that time known to have aecia with a limited mycelium on *Asclepias*, and it was suggested that he search for telial material on *Bouteloua*. Not long afterward he wrote that *Bouteloua* was not known upon Long Island, and that among the infected milkweeds, which occur on "a patch about 100 feet in length by 25 in width, many plants being actually covered from ground up, stem, leaves, and all," the only grass or sedge bearing rust was *Spartina cynosuroides*, of which he sent leaves covered thickly with telia remaining over from the preceding year, and young leaves of the season with uredinia. The *Spartina* rust

¹⁴ Bot. Gaz. 34: 13. 1902.

¹⁵ Jour. Myc. 12: 24. 1906; Mycol. 1: 236. 1909; 4: 19. 1910.

proved to be *P. Seymouriana*, and the aecia on *Asclepias* resembled those belonging to that species. Mr. Latham kindly sent viable material for cultures, collected at the same spot June 2, 1915, which was sown June 10 on plants of the four hosts used in the previous culture. Only *Asclepias syriaca* became infected, showing an abundance of pycnia June 17 and great numbers of aecia June 23.

It may fairly be concluded that this species of rust is one composed of well-marked races in accordance with the aecial hosts. Besides the three races here indicated, another doubtless occurs in connection with *Amsonia*, the characteristic aecia having been found on this host from Missouri.

7. *PUCCINIA SUBNITENS* Diet.—A collection of this rust on *Distichlis spicata*, very common in alkaline regions, was sent by Prof. H. S. Jackson from LaGrand, Ore., and sown April 15, on *Chenopodium album*. Pycnia began to show April 25, and aecia May 8, chiefly on the petioles of the leaves.¹⁶ Telial material has now been cultured from the states of Nebraska, Colorado, Delaware, Nevada, and Oregon, extending from the Atlantic to the Pacific coasts.

8. *PUCCINIA WINDSORIAE* Schw.—Much attention has been given to finding the telial host for the aecia on *Dirca palustris*, beginning with the illusory success of 1903 and continuing to the present time.¹⁷ Many telial collections have been used, secured from widely separated localities, and representing many species of rusts. During the last year a search through the herbarium for aecia on other hosts, having similar microscopic characters, led to the possibility that it might be a racial part of the common *Puccinia Windsoriae*. To test this hypothesis telial material was secured near Lafayette, on *Tridens flavus*, from the vicinity of *Dirca* bushes, annually showing the lemon-yellow spots carrying the aecia. Sowings were made May 3, on *Dirca palustris*, May

¹⁶ For previous cultures see Bot. Gaz. 35: 19. 1903; Jour. Myc. 11: 54. 1905; 12: 16. 1906; 13: 197. 1907; 14: 15. 1908; Mycol. 1: 234. 1909; 2: 225. 1910; and 4: 18, 54. 1912.

¹⁷ For previous attempts see Jour. Myc. 10: 19. 1904; 11: 56. 1905; 13: 191, 192, 196. 1907; 14: 12. 1908. Mycol. 1: 231. 1909; 2: 219, 227. 1910; 4: 9, 10, 11, 12. 1912; 7: 64, 65. 1914.

22, on *Dirca* and *Ptelea trifoliata*, May 24, on *Ptelea*. Only on *Ptelea* was infection secured, abundant pycnia showing from both sowings June 2, and aecia June 7.¹⁸

SUCCESSFUL CULTURES REPORTED NOW FOR THE FIRST TIME.—The following species have never before been cultivated in America or elsewhere, so far as the writer knows.

1. *PUCCINIA TUMIDIPES* Peck.—Excellent telial material of this species on *Lycium pallidum*, was sent by Mr. W. A. Archer, collected in the Organ Mountains, N. Mex., on Oct. 9, 1914. As it was found the teliospores would germinate, it was sown Dec. 1, 1914, on plants of *Lycium vulgare*, giving a few pycnia only by Dec. 18, with no further development, possibly owing to the poor condition of the host plant. It was sown again on another plant of the same sort Dec. 12, 1914, giving rise to a few groups of pycnia by Dec. 21, and a single uredineal sorus Jan. 16, 1915.

Although the growth of the fungus was not vigorous, and did not continue to the final stage, yet it seems safe to conclude that the rust is autoecious, and without cupulate aecia. It clearly belongs in the genus *Bullaria*, where it becomes *B. tumidipes* (Peck) comb. nov.

2. *PUCCINIA DISTICHLIDIS* Ellis & Ev.—This rust in the first place was sent to Mr. Ellis in 1891 by F. D. Kelsey of Helena, Mont., and labeled as on "*Distichlis maritima*," but afterward was shown by the writer¹⁹ to be on *Spartina gracilis*. On account of this erroneous determination of the host plant, the rust was renamed *P. Kelseyi* by Sydow.²⁰ In a study of "Correlation between certain species of *Puccinia* and *Uromyces*" Orton²¹ came to the conclusion from a comparison of the morphological characters and geographical distribution of *Uromyces Spartinae* and the rust in hand, that it was "extremely probable that its aecial host is some member of the primrose family, perhaps *Steironema*," this being one of the aecial hosts for the *Uromyces*. It has been

¹⁸ For previous successful cultures see Bot. Gaz. 29: 273. 1900; 35: 16. 1903; Jour. Myc. 11: 56. 1905.

¹⁹ Bull. Lab. Nat. Hist. Univ. Iowa 5: 324. 1902.

²⁰ Sydow, Monog. Ured. 1: 806. 1904.

²¹ Mycol. 4: 202. 1912.

difficult to locate this rust in localities from which culture material could be secured. Dr. Brenckle sent material from Kulm, N. Dak., from which cultures were attempted in 1909 and 1910²² upon a score of different hosts, but not including *Steironema*. Again material on *S. Michauxiana* was obtained from Dr. Brenckle, collected April 8, 1915, at Kulm, N. Dak., and also from Rev. J. M. Bates, collected April 20, 1915, at Loup City, Neb.

The North Dakota material was sown May 8, on *Steironema ciliatum*, and pycnia began to show May 16, followed by an abundance of aecia May 22. The Nebraska material was sown May 8, on *Steironema ciliatum* and *Polemonium reptans*. The *Polemonium* plant remained uninfected, but many pycnia began to show on the *Steironema* May 14, followed by a great abundance of aecia May 20. Although these cultures were exceedingly vigorous and in so far seemed beyond question, yet there exists a possible small source of error. The correlated *Uromyces* is a common rust, and occasionally grows upon the same leaves with the *Puccinia*. In the Nebraska material no admixture could be found, but there were sori of *Uromyces* on the North Dakota material. Care was exercised, however, to avoid all sori with one-celled spores in making the cultures, and as the two forms were mostly on separate leaves, there is little reason to doubt that the cultures were pure. Correctness of the general conclusion was obtained from a wholly independent source, however, when Dr. Brenckle sent a collection of aecia on *Steironema ciliatum*, made by Prof. O. A. Stevens near Fargo, N. Dak., May 23, 1915. On June 5 Dr. Brenckle accompanied Prof. Stevens to the spot where the collection was made, to institute a search for *Spartina*, as Prof. Stevens had reported that the grass did not grow within miles of the place. Dr. Brenckle writes, June 16, that he "found a small isolated bunch of *Spartina* in the midst of the infected spot; the rust on the *Spartina* was *Puccinia*!" The collection of aecia has been issued as Fungi Dakotenses 316, under the name of *Puccinia Distichlidis*. This is the only field collection of aecia positively known to belong to the *Puccinia* form.

3. PUCCINIA MONTANENSIS Ellis.—There has been much con-

²² Mycol. 2: 219. 1910; 4: 11. 1912.

fusion in the application of this name. Not until within the present year has it been possible to secure a clearly defined set of characters with which to delimit the species, especially to distinguish it from *Puccinia Agropyri* E. & E., with which it often grows, and which it resembles in gross appearance. It is now found to be separable from *P. Agropyri*, by the slightly thinner-walled urediniospores, having more pores (8 to 10, instead of 6 to 8 in *P. Agropyri*), sometimes accompanied by paraphyses, but more especially by the far broader teliospores (18 to 34 μ wide, against 13–24 μ in the other species), which generally approximate an oblong form with convex sides, in contrast with terete spores usually with straight sides in *P. Agropyri*.

The rust in question has often been labeled *P. apocrypta* E. & T. The type of *P. apocrypta* was collected at Canon City, Colo., August 21, 1887, and was recorded as on *Asprella Hystrix*. The type collection is now in the herbarium of the Missouri Botanical Garden, and has been carefully examined by a number of students of the grasses. The specimen is scanty, and consists of leaves only. It can not be the species of grass named, which does not occur within the region. It seems most likely to be some species of *Sitanion* possibly *S. elymoides*, a common species of the region much resembling *Hystrix*. The rust is certainly *P. Agropyri*, although the teliospores are rather broader than usual. The type material of *P. montanensis*, which is in the herbarium of the New York Botanical Garden, has been examined and bears out the published statement that it is on *Elymus condensatus*. It was collected at Helena, Mont., July 25, 1891, by F. D. Kelsey.

The fortunate observation which led to the elucidation of this species was made by Mr. A. O. Garrett, of Salt Lake City, Utah, who wrote on May 23, 1915: "I am sending by this mail some leaves of *Hydrophyllum [capitatum]* heavily infected with *Aecidium Hydrophylli*. I think this rust has the alternate stage on *Agropyron*. I always find the *Agropyron* plant plentiful, and it is affected by the rust, wherever the *Hydrophyllums* grow." The aecia on *Hydrophyllum* sent by Mr. Garrett came in good condition, and were sown May 28, on *Agropyron tenerum* and *Elymus virginicus*. Uredinia began to show in abundance June 7, on the

Agropyron, followed by telia June 11. On the *Elymus* only a few uredinia developed, not observed until June 23. A study of the uredinia and telia on the *Agropyron* disclosed the characters of *Puccinia montanensis*. Field observations by Dr. Brenckle of North Dakota, Mr. Garrett of Utah, and Mr. Bethel of Colorado, independently reported, associated aecia on *Lithospermum*, *Onosmodium*, and *Phacelia*, with *Agropyron* and *Elymus* rust, but material sent to establish the connection by cultures failed to yield results. Subsequent herbarium studies leave little chance for doubt that *Puccinia Agropyri* has its alternate form on Ranunculaceous hosts, while *P. montanensis* has its alternate form on Hydrophyllaceous and Borraginaceous hosts.

Two former attempts at culture of *P. montanensis*²³ are shown by a reexamination of the original material to have been made by using *P. Agropyri*, and not *P. montanensis*, as published.

4. UROMYCES HORDEI Tracy.—Telial material on *Hordeum pusillum* Nutt., sent by F. McAllister and B. C. Tharp from Austin, Texas, was sown March 15, on *Nothoscordium striatum* and *Ornithogalum umbellatum*, and again March 30 on the latter host, with infection only on the *Nothoscordium*, showing pycnia March 30, and aecia April 6, both strongly developed.

When the report of culture experiments for the years 1911 to 1913 by W. Tranzschel²⁴ came to hand, the account of the successful growth of barley rust on *Ornithogalum umbellatum* suggested the renewal of a study of the correlated American species of *Uromyces*, *U. Hordei* Tracy. There is no morphological difference between the uredinia and telia of the latter species and those of *Puccinia anomala* Rostr. (*P. simplex* Eriks. & Henn.), except that part, rarely all, of the teliospores of the *Puccinia* are two-celled. *Ornithogalum umbellatum* is the Star-of-Bethlehem of the florists, and has escaped from gardens and become a weed in the southern states as far northward as the Ohio river. Aecia on it have not been reported for America, but they are known on a near relative, *Nothoscordium bivalve* (L.) Britton (*Ornithogalum bivalve* L.), from Texas. An appeal to Dr. McAl-

²³ Jour. Myc. 14: 11. 1908; and Mycol. 1: 11. 1912.

²⁴ Mycol. Centr. 4: 70. 1914.

lister and Mr. Tharp, of the University of Texas, made in November, 1914, soon placed in my possession resting telia on *Hordeum pusillum* and dormant bulbs of the *Nothoscordium*, which were made to yield the above results.

In the meantime it was remembered that Mr. W. H. Long had reported this connection several years before. In a letter dated Feb. 28, 1904, he says: "I have successfully grown *Uromyces Hordei* urediniospores from sowings of aeciospores that I find on *Nothoscordium striatum* [*N. bivalve*]." Again on March 24, 1910, Mr. Long wrote: "Since writing you last I have cross-inoculated teliospores on *Nothoscordium striatum*, and aeciospores from it upon *Hordeum nodosum* [error for *H. pusillum*], and got successful cultures in both instances." Mr. Long kindly sent material to illustrate his work and also material with which to verify his conclusions. Unfortunately it was not possible to bring about conditions for the cultures, and as Mr. Long's work was done in the open, and not verified by others, the results were omitted from the North American Flora when this species was reached.²⁵

In this connection it may be well to say that the statement in the North American Flora that the species occurs in California on *Hordeum nodosum* is erroneous. The species ranges from Nebraska to Mississippi and Texas, which also includes the range of the aecial host, although the aecia have only been taken in Texas.

SUMMARY

The following is a complete list of the successful cultures made during the year 1915. It is divided into two series, species that have previously been grown in cultures and reported by the writer or other investigators, and species whose culture is now reported for the first time.

A. SPECIES PREVIOUSLY REPORTED

1. PUCCINIA EXTENSICOLA Plowr. (*P. Dulichii* Syd.).—Teliospores from *Dulichium arundinaceum* (L.) Britt., sown on *Solidago canadensis* L.

²⁵ N. Amer. Flora 7: 228. 1912.

2. PUCCINIA GROSSULARIAE (Schum.) Lagerh. (*P. uniporula* Orton).—Teliospores from *Carex tenuis* Rudge, and from *C. arctata* Boott, sown on *Ribes cynosbati* L.

3. PUCCINIA ERIOPHORI Thüm.—Aeciospores from *Senecio aureus* L., sown on *Eriophorum viridi-carinatum* (Engelm.) Fernald.

4. PUCCINIA AGROPYRI Ellis & Ev. (*P. alternans* Arth.).—Teliospores from *Festuca Thurberi* Vasey, sown on *Thalictrum dioicum* L.

5. PUCCINIA ASPERIFOLII (Pers.) Wettst.—Teliospores from *Secale cereale* L., sown on *Anchusa officinalis* L.

6. PUCCINIA SEYMOURIANA Arth. (*Aecidium obesum* Arth.).—Teliospores from *Spartina Michauxiana* Hitchc., sown on *Apo-cynum cannabinum* L., and from *Spartina cynosuroides* (L.) Roth, sown on *Asclepias syriaca* L.

7. PUCCINIA SUBNITENS Diet.—Teliospores from *Distichlis spicata* (L.) Greene, sown on *Chenopodium album* L.

8. PUCCINIA WINDSORIAE Schw.—Teliospores from *Tridens flavus* (L.) Hitchc. (*Tricuspis seslerioides* Torr.), sown on *Ptelea trifoliata* L.

B. SPECIES REPORTED NOW FOR THE FIRST TIME

1. PUCCINIA TUMIDIPIPES Peck.—Teliospores from *Lycium pallidum* Miers, sown on *L. vulgare* Dunal, producing pycnia and uredinia.

2. PUCCINIA DISTICHLIDIS Ellis & Ev.—Teliospores from *Spartina Michauxiana* Hitchc., sown on *Steironema ciliatum* (L.) Raf.

3. PUCCINIA MONTANENSIS Ellis (*Aecidium Hydrophylli* Peck).—Aeciospores from *Hydrophyllum capitatum* Dougl., sown on *Agropyron tenerum* Vasey and *Elymus virginicus* L.

4. UROMYCES HORDEI Tracy.—Teliospores from *Hordeum pusillum* Nutt., sown on *Nothoscordium bivalve* (L.) Britton.

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